# Extending and validating a human papillomavirus (HPV) knowledge measure in a national sample of Canadian parents of boys

Samara Perez[a,b,*], Ovidiu Tatar[b], Remo Ostini[c], Gilla K. Shapiro[a,b], Jo Waller[d], Gregory Zimet[e], Zeev Rosberger[a,b,f]

[a]Department of Psychology**,** McGill University
1205 Dr. Penfield Avenue
Montreal Quebec, Canada H3A 1B1

[b]Lady Davis Institute for Medical Research, Jewish General Hospital
4333 Cote Ste-Catherine Road
Montreal, Quebec, Canada H3T 1E4

[c]Rural Clinical School Research Centre, School of Medicine
The University of Queensland Centre for Health Sciences Research
University of Southern Queensland, Rm. Q338
West Street, Toowoomba Qld 4350, Australia

[d]Cancer Research UK Health Behaviour Research Centre
Department of Epidemiology and Public Health
UCL, 1-19 Torrington Place
London, United Kingdom WC1E 6BT,

[e]Indiana University School of Medicine
Section of Adolescent Medicine
410 West 10th Street, HS 1001
Indianapolis, IN 46202, USA

[f]Louise Granofsky-Psychosocial Oncology Program, Segal Cancer Center
Jewish General Hospital
4333 Cote Ste-Catherine Road
Montreal, Quebec, H3T1E4

*****Corresponding author

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## Abstract

As the human papillomavirus (HPV) vaccine is now recommended for males, a reliable, comprehensive HPV knowledge measurement tool which addresses issues relevant to males is needed. We aimed to replicate, validate and test the comprehensiveness of an existing general HPV and an HPV vaccination knowledge scale in English and French. We also measured parental HPV knowledge and changes over time. An online questionnaire was administered in February (Time 1; T1) and November 2014 (Time 2; T2) to a nationally representative sample of Canadian parents of boys. Dimensionality, internal consistency and model fit were evaluated at both time points and separately in English and French sub-samples. Differences in knowledge scores were measured. Analyses were performed on 3117 participants at T1 and 1427 at T2. The 25-item HPV general knowledge and an 11-item HPV vaccination scale were uni-dimensional, showed high internal consistency ($\alpha>0.87$, $\alpha>0.73$) and had good model fit. Both general HPV and vaccine-specific knowledge significantly increased over time in both languages, but remained low at T2, with only about half of the items being answered correctly. Correct responses at T2 are best explained by correct responses at T1, with some small changes from 'Don't know' at T1 to correct at T2.

The extended general and vaccine-specific knowledge scales are valid, reliable and comprehensive, and could be used among parents of boys, in both English and French. Educational interventions could target specific knowledge gaps and focus on providing information rather than correcting misconceptions.



**Keywords:** Human papillomavirus (HPV); Papillomavirus vaccines; Papillomavirus Infections/prevention & control; Knowledge; Health Knowledge, Attitudes, Practice; Measure; Parents; Males; Acceptability

## Introduction

Strong empirical evidence supports the causal role of the human papillomavirus (HPV) in the development of cervical, vaginal, penile, anal and oropharyngeal cancers and genital warts (Forman et al., 2012; Vardas et al., 2011). In Canada, all provinces and territories vaccinate females against HPV as part of provincial school-based immunization programs i.e., grades 4 through 8 (~10-14 years old), dependent on location(Shapiro et al., 2016). Most organizations now also recommend HPV immunization for males (Centers for Disease Control and Prevention, 2015; Public Health Agency of Canada, 2015; WHO Report, 2015). In Canada, the HPV vaccine has been included for boys in school-based provincial immunization programs, with other provinces due to follow in the autumn 2016 (e.g. Alberta (autumn 2014), Prince Edward Island (PEI) (autumn 2013), and Nova Scotia (autumn 2015) for grade 5, 6 and 7 (~11-13 years old), respectively. Quebec and Manitoba are set to begin programs (autumn 2016) for boys in grades 4 and 6 respectively (Public Health Agency of Canada, 2016; Shapiro et al., 2016).Across many parts of Canada, HPV vaccination uptake for girls is not reaching the ~70% needed to provide herd protection (Brisson et al., 2011; Public Health Agency of Canada, 2014). Data from the first male HPV immunization program in PEI indicates that although HPV vaccination uptake was high (79% for males and 85% for females), grade six girls had a 1.5 higher likelihood of being vaccinated compared to boys of the same age (McClure et al., 2015). In this early period where male HPV vaccination programs are being initiated, there is a need to understand what influences parental decision-making concerning HPV vaccination for their sons.

Psychosocial research examining the factors that influence HPV vaccination acceptance suggests a direct relationship exists between parents' HPV and HPV vaccine knowledge and intentions to vaccinate against HPV (Allen et al., 2010; Giambi et al., 2014; Pelucchi et al., 2010). A comprehensive measurement of parents' HPV knowledge is important to target HPV vaccine specific knowledge gaps, web designing and implementing educational interventions, aimed at increasing HPV vaccine uptake. A reliable HPV general knowledge and HPV vaccination specific knowledge scale was developed and validated by Waller and colleagues (2013). While the scales were extensively psychometrically tested and found to be structurally cohesive and reliable, they do not capture knowledge items relevant to males (e.g., did not assess knowledge about HPV-associated diseases *beyond* cervical cancer) and were only validated among English speakers. Waller et al. concluded with the recommendation to validate the measure in other settings and languages and to examine the addition of new items particularly when the HPV vaccine becomes readily available for males.

The present study's objectives were 1) to replicate the validation of the general HPV and HPV vaccine knowledge scales proposed by Waller and colleagues among a national sample of both English and French-speaking Canadian parents of boys; 2) to examine whether our additional items add to the comprehensiveness and cohesiveness of the existing general HPV knowledge and HPV vaccine scales and; 3) to measure and describe general HPV and HPV vaccine knowledge patterns of change over time.

## Methods

### *Study Participants and Design*

Parents who had a son aged 9-16 years old living in their household were recruited through a research firm, Leger Marketing, which maintains a representative panel of 400,000 Canadian households. We targeted a sample of 4,000 parents, weighted according to the population distribution of the ten Canadian provinces. In February 2014, panel participants who met the inclusion criteria were sent an invitation email with a link to the online study. Participants elected whether they preferred to answer the questionnaire in English or French.

Data were collected using an online questionnaire that took approximately 20 minutes to complete and contained a variety of quantitative and qualitative items including: socio-demographics, knowledge, HPV vaccination attitudes, and health behaviors. The focus of this study is on the HPV and HPV vaccine knowledge items. Participants who completed the questionnaire at Time 1 (T1) and deemed eligible respondents were invited to re-complete the questionnaire at 9-months follow up (November 2014, Time 2, (T2)). The study was approved by the Research Ethics Board at the Jewish General Hospital, Montreal, Canada. A detailed methodology of the study protocol and sample characteristics is provided elsewhere (Perez, S. et al., Determinants of parental human papillomavirus (HPV) vaccine decision-making for sons: Methodological challenges and initial results of a pan-Canadian longitudinal study, under review).

### *Knowledge Items*

The authors expanded upon the HPV-general knowledge (herein referred to as GK) and the HPV-vaccine knowledge (herein referred to as VK) scales published by Waller et al (2013), who, using a Principal Axis Factor Analysis (PFA), found that both a 16-item HPV knowledge subscale, GK ($\alpha$=0.849) and the 7-item HPV vaccination knowledge subscale, VK ($\alpha$= 0.561) were reliable and uni-dimensional (2013). Results of the Confirmatory Factor Analysis (CFA) suggested a better fit for the 16-item GK scale than for the 7-item VK scale.

The present study included the identical Waller et al.'s 16-item GK scale with two minor semantic changes (shown in italics): "HPV can be *transmitted* through general skin-to-skin contact" and "Using condoms reduces the *chances* of HPV transmission[1]." Our study also included the identical Waller et al.'s 7-item VK scale with one semantic change: "Girls who have had the HPV vaccine do not need a Pap test *(cervical cancer screening)* when they are older[2]". It was also necessary to slightly revise one of the VK items about dosing as since Waller et al.'s (2013) publication, the WHO recommendation(WHO Report, 2015) had shifted from a

[1]Waller's items: HPV can be *passed* on during sexual intercourse; Using condoms reduces the *risk* of getting HPV
[2]Waller's items: Girls who have had the HPV vaccine do not need a [Pap test/Smear test/Pap smear test] when they are older

three to a two-dose policy for children under 15 years of age ("The HPV vaccine requires only *one dose*[3]"). Response options were identical to Waller's scale and used forced choice response categories of True/False/Don't know.

Based on our previous HPV research (Krawczyk et al., 2015; Krawczyk et al., 2013; Krawczyk et al., 2012), consultation with an expert panel and a comprehensive literature search, we identified additional knowledge items that were not included in Waller's scale. These items reflected the most up-to-date emerging scientific evidence and were frequently being measured in the HPV psychosocial/epidemiological literature (Daley et al., 2009; Daley et al., 2010; Fisher, Personal communication; Gerend and Barley, 2009; Giede et al., 2010; Gutierrez et al., 2013; Katz et al., 2011). The addition of the 9 GK (see Appendices A & B; items 17- 25 for the new added items) and 4 VK items (see Appendices A & B; items 8- 11 for the new added items) aimed to measure: 1) the association of HPV with oral, penile, and anal cancers (items 17, 20, 24), 2) transmission (items 19, 22, 25), 3) HPV-associated signs and symptoms (items 18, 21, 23), 4) prevention (items 8), 5) treatment (item 9), 6) the recommendation for males and females in the Canadian context (items 10,11) (see Appendices A & B).

Questionnaire development took into account language and literacy levels. The entire questionnaire was pilot tested for readability and validity with 20 parents of 9-16-year-old boys. The reading level of the survey was measured using the Flesch-Kincaid scale available through Microsoft Word (Microsoft Corp., Redmond, WA) and found to be appropriate for a grade 8 reading level. The English survey was translated into French by a specialized translation firm with expertise in health literacy and reviewed for accuracy by an independent bilingual group of professionals ($n$=5) working in the healthcare field. Questionnaire development and translation was reviewed by a bilingual panel of seven highly experienced HPV researchers.

GK and VK scores were calculated by assigning 1 point to each correct answer and zero points for incorrect or 'Don't know' answers (Range= 0-25 for GK and range=0-11 for VK). A GK and VK total score were calculated at baseline (Time 1, T1) and at 9-months follow up (Time 2, T2) for the English and French sub-samples.

**Analysis**

Analyses were performed on the T1 and T2 samples separately, which were also divided into two sub-samples, English and French respondents. Analyses included internal consistency analysis (Cronbach's alpha), exploratory factor analysis (EFA) to investigate dimensionality and a CFA to investigate validity (model fit). Results for the 16-item GK scale and the 7-item VK scale in French and English were compared with the results obtained by Waller et al. (2013). The effects of adding nine new GK items and four new VK items on internal consistency and dimensionality were then investigated by comparing the scale properties with and without the

[3]Waller's item: HPV vaccines require three doses

additional items. Additionally, descriptive statistics and Welch two sample *t*-tests, $p < 0.05$ were used to explore knowledge scores over time and across languages.

For the EFA, a PFA was used with varimax rotation. Similar to Waller's analysis, four criteria (Slocum-Gori and Zumbo, 2010) were used to explore dimensionality; three criteria are presented in Table 2. Results for the fourth criterion, examining items that did not load higher than 0.33 on a forced one-factor solution, are presented in text. For the CFA, results are based on four indices (Hu and Bentler, 1999) (see Table 3 and Table 4). Differences in proportions were tested using Chi-square, $p<0.05$. Statistical analysis was conducted using SPSS v21, Stata 13 and R Studio v0.99.896.

## Results

At T1 *n*=3117 respondents and at T2, *n*= 1427 respondents were included in the analysis. At T1, 2117 participants from T1 completed the questionnaire in English and 1000 in French. At T2, 873 participants completed the questionnaire in English and 554 completed it in French.

### *Internal Consistency Analysis*

The internal consistency results for the GK16 compared favorably with the results obtained by Waller et al. The internal consistency of the GK25 was higher than GK16 across all subsamples (Table 1). Item level analysis indicated that the item "HPV usually doesn't need any treatment" sometimes had a slightly negative effect (in the third decimal place) on scales' internal consistency.

Internal consistency values for the VK7 and VK11 subscales were higher than those found by Waller et al. (Table 1). Item specific analysis suggested a slight misfit for the item "One of the HPV vaccines offers protection against genital warts" but the effect was very small**.**

**Table 1** Internal Consistency (Cronbach's alpha) of HPV General Knowledge (GK) and HPV Vaccine Knowledge (VK) across subsamples at Time 1 (T1) and Time 2 (T2).

| | | HPV general knowledge (GK) | | HPV Vaccine Knowledge (VK) | |
|---|---|---|---|---|---|
| | | GK16 | GK25 | VK7 | VK11 |
| T1 | French (*n* = 1000) | 0.869 | 0.902 | 0.699 | 0.778 |
| | English (*n* = 2117) | 0.898 | 0.922 | 0.733 | 0.819 |
| | Combined (*n* = 3117) | 0.889 | 0.916 | 0.722 | 0.807 |
| T2 | French (*n* = 554) | 0.828 | 0.874 | 0.651 | 0.737 |
| | English (*n* = 873) | 0.855 | 0.894 | 0.619 | 0.742 |
| | Combined (*n* = 1427) | 0.844 | 0.887 | 0.629 | 0.739 |

Note. Waller et al. GK (16 items) $\alpha = 0.849$; Waller et al. VK (7 items) $\alpha = 0.561$

***Dimensionality Analysis (EFA)***

For the GK16, on all subsamples and at both time points, we obtained only one factor with Eigenvalue (EV) >1; the extracted loading of factor one was more than three times larger than factor two (F1>3xF2); and the one factor percentage of common variance (1FVar) was higher than the reference value (27.78) from Wallers' scale (2013), with one exception. Item level analysis found that the item "HPV usually doesn't need any treatment" failed to load greater than .33 on a 1-factor solution for all subsamples and at both time points.

For the GK25, the criteria F1 > 3xF2 and 1FVar were met (Table 2) for all subsamples and at both time points. At T1 and T2, the percentage of common variance accounted for in the French language sample was lower than that of the English sample (Table 2). A consistent finding, with the exception of the T1 combined sample, was that the addition of the nine new items (GK25) resulted in three factors with EV greater than 1 (Table 2). Similar to the GK16, the item "HPV usually doesn't need any treatment" failed to load greater than .33 on a 1-factor solution. The item "HPV can cause herpes" also failed to load greater than .33 on a 1-factor solution for the French language at the second time point.

EFA results for VK7 and VK11 across both language subsamples and at both time points found only one factor with an EV > 1 (Table 2). In almost all cases, F1 was > 3xF2 (Table 2). For both the VK7 and the VK11

and across all subsamples, the percentage of variance accounted for by a 1-factor solution was higher (22.17-31.39) than the percentage of variance obtained by Waller et al. (21.65). Item level analysis indicated that for both the VK7 and the VK11, most items loaded >0.33 on the one factor solution for all subsamples at both time points. The item “One of the HPV vaccines offers protection against genital warts” frequently failed to load >0.33 and the items “The HPV vaccines offer protection against most cervical cancers” and “The HPV vaccine only requires one dose” occasionally failed to load >0.33.

**Table 2.** Results of the Exploratory Factor Analysis on all subsamples

| | | GK16 | | | GK25 | | | VK7 | | | VK11 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EV>1 | F1>3xF2 | 1FVar | EV>1 | F1>3xF2 | 1FVar | EV>1 | F1>3xF2 | 1FVar | EV>1 | F1>3xF2 | 1FVar |
| **T1** | French (*n* =1000) | One | Yes | 31.35 | Three | Yes | 27.9 | One | Yes | 26.61 | One | Yes | 26.32 |
| | English (*n* = 2117) | One | Yes | 37.18 | Three | Yes | 33.09 | One | Yes | 31.39 | One | Yes | 31.12 |
| | Combined (*n* = 3117) | One | Yes | 35.26 | Two | Yes | 31.32 | One | Yes | 30.38 | One | Yes | 29.48 |
| **T2** | French (*n* = 554) | One | Yes | 26.03 | Three | Yes | 23.26 | One | No* | 25.26 | One | Yes | 22.85 |
| | English (*n* = 873) | One | Yes | 29.72 | Three | Yes | 27.04 | One | No* | - | One | Yes | 22.28 |
| | Combined (*n* = 1427) | One | Yes | 28.13 | Three | Yes | 25.38 | One | No* | - | One | Yes | 22.17 |

*Note.* EV= Eigenvalue; EV>1= number of factors with EV>1; F1>3xF2=extracted loadings of factor1 three times bigger than factor 2; 1FVar= 1 factor % common variance; * =very close to yes. Waller's results for the 16-item GK scale were: EV>1=one; F1>3xF2=Yes; 1FVar=27.78. Waller's results for the 7-item VK scale were: EV>1=1; F1>3xF2=No; 1FVar=21.65.

***Model fit (CFA)***

CFA analysis for the GK16 and the GK25 found that the Standardized Root Mean Square Residual (SRMR) and the Coefficient of Determination (CD) values met the suggested model fit criteria (Hu and Bentler, 1999). The Comparative Fit Index (CFI) values were close to the cutoff criteria while the *p* value for Chi square and Root Mean Square Error Approximation (RMSEA) criteria for model fit were not met (Table 3). For the VK7 and the VK11, previous observations related to cut-off criteria for the GK scales apply (Table 4).

**Table 3.** Results of the Confirmatory Factor Analysis for the 16 and 25-item HPV General Knowledge (GK) scales

| | | GK16 | | | | | GK25 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $\chi^2$ | CFI | RMSEA | SRMR | CD | $\chi^2$ | CFI | RMSEA | SRMR | CD |
| **T1** | French (*n* =1000) | 889.15 *p*<.001 | .843 | .087 | .055 | .900 | 2571.48 *p*<.001 | .725 | .091 | .071 | .916 |
| | English (*n* =2117) | 1311.88 *p*<.001 | .905 | .074 | .042 | .918 | 4807.88 *p*<.001 | .784 | .088 | .066 | .933 |
| | Combined (*n* = 3117) | 2054.54 *p*<.001 | .889 | .078 | .045 | .912 | 7185.70 *p*<.001 | .764 | .090 | .068 | .927 |
| **T2** | French (*n* =554) | 484.63 *p*<.001 | .853 | .081 | .055 | .895 | 1435.47 *p*<.001 | .729 | .087 | .073 | .911 |
| | English (*n* =873) | 588.96 *p*<.001 | .904 | .073 | .045 | .916 | 2308.79 *p*<.001 | .766 | .092 | .070 | .931 |
| | Combined (*n* = 1427) | 948.23 *p*<.001 | .889 | .075 | .047 | .908 | 3518.88 *p*<.001 | .749 | .091 | .071 | .923 |

*Note.* $\chi^2$=Chi square; CFI= comparative fit index; RMSEA= root mean square error approximation; SRMR= standardized root mean square residual; CD= coefficient of determination.

Cut-off criteria: a) p for $\chi^2$> 0.05, b) CFI > 0.9, c) RMSEA<0.06, d) SRMR<0.08 and e) CD as close as possible to 1. Waller et. al results: Chi square 1981.6, p<0.0001; CFI=.816; RMSEA=.087; SRMR=.063; NFI=.809

**Table 4.** Results of the Confirmatory Factor Analysis for the 7 and 11-item HPV Vaccination Knowledge (VK) scales

| | | VK7 | | | | | VK11 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $X^2$ | CFI | RMSEA | SRMR | CD | $X^2$ | CFI | RMSEA | SRMR | CD |
| **T1** | French (*n* =1000) | 128.21 *p*<.001 | .908 | .090 | .052 | .804 | 294.02 p<.001 | .883 | .075 | .050 | .832 |
| | English (*n* =2117) | 226.19 p<.001 | .930 | .085 | .049 | .822 | 576.73 p<.001 | .909 | .076 | .048 | .863 |
| | Combined (*n* = 3117) | 335.48 p<.001 | .925 | .086 | .049 | .815 | 834.75 p<.001 | .901 | .076 | .048 | .853 |
| **T2** | French (*n* =554) | 68.86 p<.001 | .899 | .084 | .052 | .767 | 174.02 p<.001 | .870 | .073 | .053 | .805 |
| | English (*n* =873) | 104.61 p<.001 | .917 | .086 | .053 | .799 | 275.40 p<.001 | .896 | .078 | .051 | .850 |
| | Combined (*n* = 1427) | 154.44 p<.001 | .914 | .084 | .051 | .786 | 409.95 p<.001 | .886 | .076 | .050 | .833 |

*Note.* $\chi^2$=Chi square; CFI= comparative fit index; RMSEA= root mean square error approximation; SRMR= standardized root mean square residual; CD= coefficient of determination.

Cut-off criteria: a) p for $\chi^2$> 0.05, b) CFI > 0.9, c) RMSEA<0.06, d) SRMR<0.08 and e) CD as close as possible to 1. Waller et. al results: Chi square 428.9, p<0.0001; CFI=.793; RMSEA=.111; SRMR=.083; NFI=.789

### *GK across Time and Language*

Consistently, for every single item for both the English and French subsamples, there was an increase in the proportion of correct responses from T1 (n=3117) to T2 (n=1427). This increase was significant for 24 from 25 items for the English sample and 21 from 25 items for the French sample. For example, two items with the largest significant increase (12-25%) over time in both English and French were "Men cannot get HPV" and "HPV can cause cancer of the penis". Importantly, the overall mean GK25 score significantly increased for both languages across time ($Mean_{EN}$ at T1=11.76; $Mean_{EN}$ at T2=14.23, t=9.78, CI [1.97; 2.95] and $Mean_{FR}$ at T1=11.47; $Mean_{FR}$ at T2=13.69, t=7.35, CI [1.63; 2.82]).

There were differences in the proportion of correct answers at the item level between English and French samples at both time points i.e., 18 from 25 items significantly differed between French and English samples at T1 and 15 from 25 significantly differed between French and English samples at T2. Importantly, there was no significant difference between the overall mean GK25 score for the two languages at either time point ($Mean_{EN}$=11.76 and $Mean_{FR}$= 11.47 at T1) and ($Mean_{EN}$= 14.23 and $Mean_{FR}$=13.69 at T2).

### *VK across Time and Language*

An identical pattern as GK25 was found for VK11. There was an increase in the proportion of correct responses for every single item for both the English and French subsamples from T1 (n=3117) to T2 (n=1427). This increase was significant for 11 of 11 items for the English sample and 9 of 11 items for the French sample. For example, two items with the largest significant increase (11-27%) over time were "The HPV vaccine is approved and recommended by Health Canada for males aged 9-26 years" and "Someone who has had the HPV vaccine cannot develop cervical cancer". Importantly, the mean VK11 score significantly increased for both languages across time ($Mean_{EN}$ at T1=5.21; $Mean_{EN}$ at T2= 6.38, t=10.4, CI [0.94;1.39] and $Mean_{FR}$ at T1 =5.26 and $Mean_{FR}$ at T2 =6.17, t=6.52, CI [0.63;1.18]).

There were differences in the proportion of correct answers at the item level between English and French samples at both time points i.e., 7 of 11 items significantly differed between French and English at T1 and 4 of 11 significantly differed between FR and EN at T2. Importantly, there was no significant difference between the overall mean VK11 score for the two languages at either time point ($Mean_{EN}$=5.21 and $Mean_{FR}$= 5.26 at T1) and ($Mean_{EN}$=6.38 and $Mean_{FR}$=6.17 at T2).

### *Knowledge Patterns of Change*

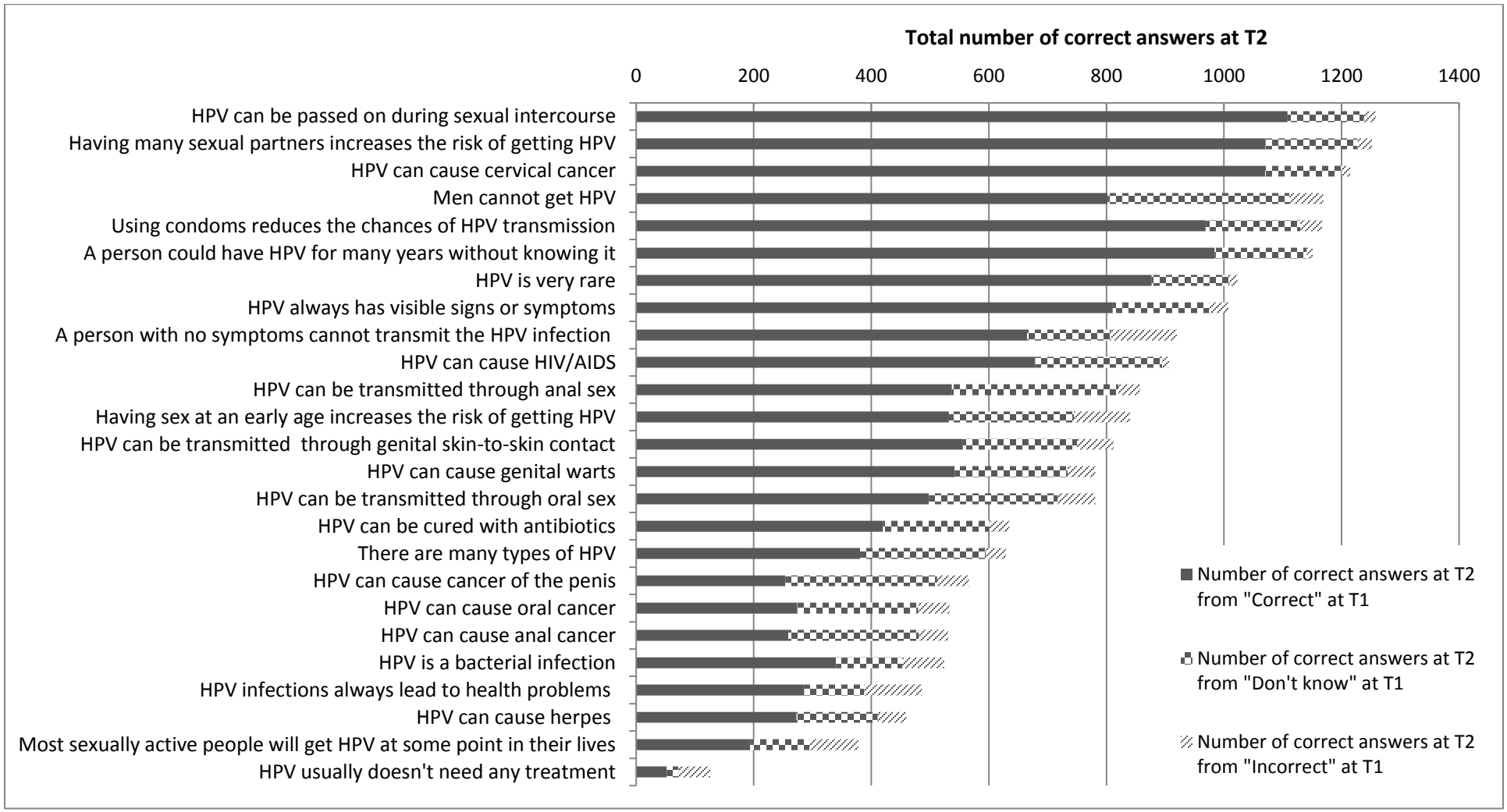
An examination of knowledge changes over time was conducted among those participants who answered the questionnaire at both T1 and T2 (*n*=1427). At T1, for the GK25, participants answered 49.1% of items correctly, 13.2% of items incorrectly and 37.7% of answers as "Don't know". At T2, at the item level, less than 50% of the sample achieved the correct answers for 10 out of 25 GK items (Figure 1). The mean

knowledge score for the GK25 scale at T1 was 12.28/25 and 14.02/25 at T2, (t=7.56, 95% CI [1.29; 2.19] p<0.001).

At T1 for the VK11, participants answered 49.9% of items correctly, 9.6% of items incorrectly and 40.5% of answers as "Don't know". At T2, at the item level, less than 50% of the sample got the correct answer for 5 out of the 11 VK items (Figure 2). The mean knowledge score for the VK11 scale at T1 was 5.49 of 11 and 6.3 of 11 at T2, (t=7.86, 95% CI [0.6; 1.0], p<0.001). The most and least known GK items at T2 are provided in Figure 1 and the most and least known VK items at T2 are provided in Figure 2.

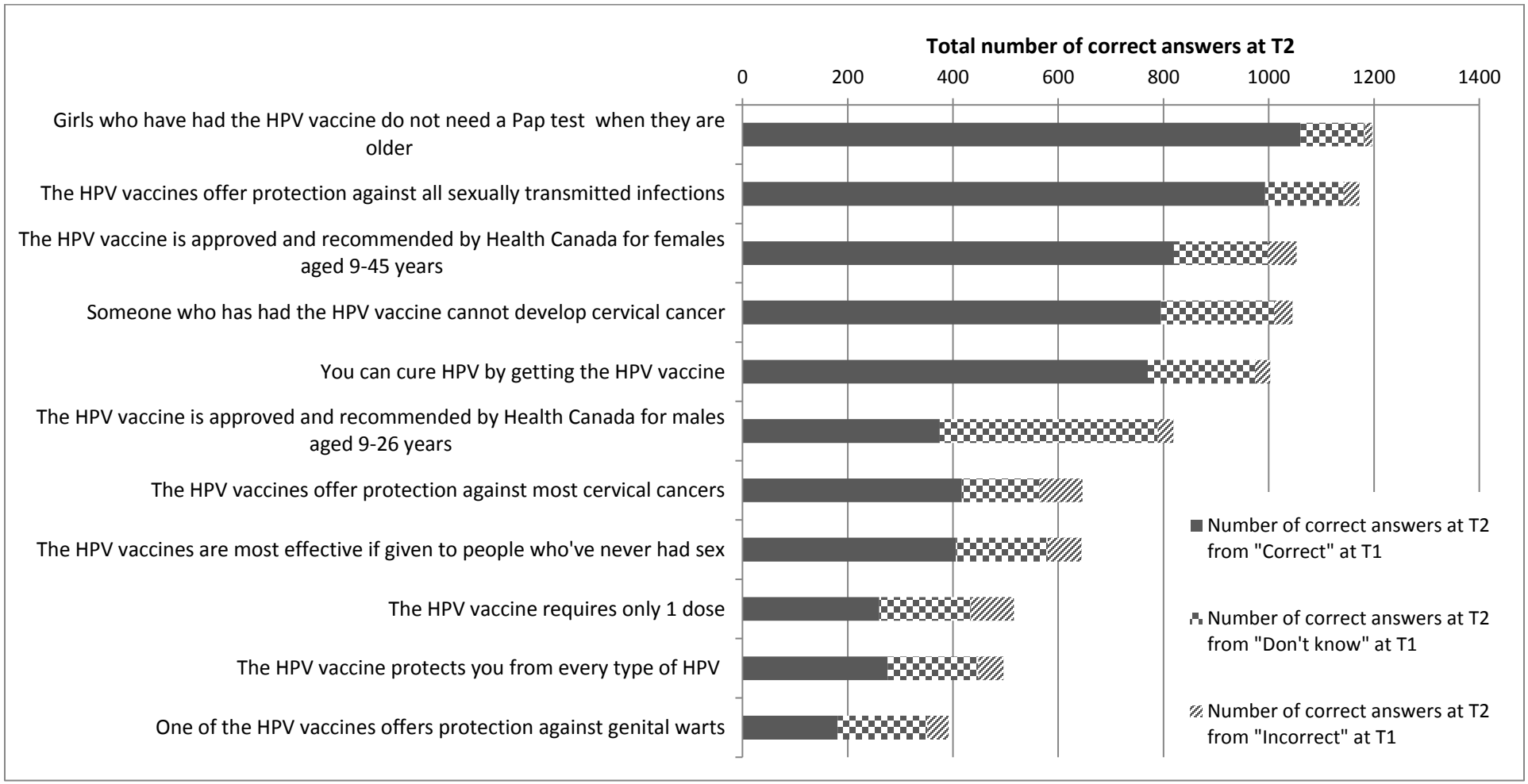
Item-level analysis of both the GK and VK scales revealed that for best known items, correct responses at T2 can be best explained by correct responses at T1 (Figure 1 and Figure 2). For both GK and VK items, few correct responses at T2 can be explained by changing from incorrect at T1Figure 1Figure 2. The number of correct responses at T2 originating from "Don't know" answers at T1 was relatively constant across items (Figure 1). For GK, the largest increase was observed for parents who did not know at T1 that: a) men can get HPV, b) HPV can cause cancer of penis and c) HPV can be transmitted through anal sex (Figure 1). For VK, the largest increase was observed for parents who did not know at T1 that the vaccine is recommended for males aged 9-26 (Figure 2).

**Figure 1.** Number of correct answers to each item at Time 2, by their answer at Time 1 for HPV General Knowledge (GK) items.




*Note.* Data is presented for *n*=1427 at T1 and *n*=1427 at T2. For each item, the entire bar represents the number of correct answers at T2. Shading represents the way in which these participants remained correct or changed to correct from their initial response at T1. For example, for the item "*HPV can be passed on during sexual intercourse*", 1108 correct answers at T1 remained correct at T2; 130 'Don't Know' answers at T1 and 20 incorrect answers at T1 changed to correct at T2.

**Figure 2.** Number of correct answers to each item at Time 2, by their initial answer at Time 1 for HPV Vaccination Knowledge (VK) items.




*Note.*

Data is presented for *n*=1427 at T1 and *n*=1427 at T2. For each item, the entire bar represents the correct number of answers at T2. Shading represents the way in which these participants remained correct or changed to correct from their initial response at T1. For example, for the item "Girls who have had the HPV vaccine do not need a Pap test when they are older", 1060 correct answers at T1 remained correct at T2; 123 'Don't Know' answers at T1 and 14 incorrect answers at T1 changed to correct at T2

## Discussion

As a replication analysis, our results support the conclusion that Waller's HPV general (GK) and HPV vaccine (VK) knowledge subscales operate as structurally coherent and reliable measures that can continue to be used in English and now in French. Investigation of the addition of the 9 new items and the 4 items to the GK and VK subscales respectively, found improved internal consistency compared to Waller et al.'s (2013), scale. The exception to this was "HPV usually doesn't need any treatment", which when removed improved reliability (although not substantially) and was by far the item which the fewest participants were able to answer correctly.

Similar to Waller et al., our hypothesis of uni-dimensionality holds for both the GK25 and the VK11 scales. Of note, for the GK25 scale, obtaining three factors with Eigenvalues greater than one is not of concern because the first factor was typically a very dominant factor such that subsequent rotated factors often involved cross-loaded items and rarely led to meaningful factors in item content terms. Item loading results for the GK25 were similar to the Waller et al.'s results. The item "HPV can cause herpes" and the item "HPV usually doesn't need any treatment" loaded poorly in both our and Waller's study.

Interestingly, knowledge of these items was very poor in our Canadian sample which is in line with other populations (Blake et al., 2015; Bynum et al., 2011; Daley et al., 2010; Gerend and Shepherd, 2011; Giambi et al., 2014; Holcomb et al., 2004; Kang and Kim, 2011; Marlow et al., 2013; Mollers et al., 2014; Yacobi et al., 1999). Future consideration should be given to excluding these items from the GK scales as perhaps they are not necessary to understanding HPV and may be confusing (e.g., *HPV itself* does not require any treatment but *HPV-associated diseases* do require treatment) and likely unnecessary (e.g., is it relevant to know that HPV does not cause herpes). Post hoc, we explored the effect of removing these two items from the GK25 scale, and model fit remained largely unchanged and the change in internal consistency was inconsequential. The decision then to include or exclude these items would thus be left to the individual researcher, though it is our suggestion to exclude these 2 items, as it make more substantive sense, leaving a 23-item solution, the GK23.

For the VK11 scale, two items failed to appropriately load: "One of the HPV vaccines offers protection against genital warts" and "The HPV vaccine only requires one dose", which

was similarly found by Waller and colleagues (2013). These items require further attention as they are conceptually valuable for measuring HPV vaccine knowledge as the protection against genital warts may be an additional benefit to some individuals to prompt vaccination and dosage is important as we know that many parents do not complete the full vaccination series. As most countries are now only using vaccines that prevent both cancers and warts (i.e., 4vHPV and 9vHPV), and as most countries transition to the WHO recommended 2-dose schedule, it may have confused parents to inter-change HPV vaccine with ('one of the') HPV vaccine*s (plural).* We hypothesize that a slight change in wording/semantics for all VK could potentially improve model fit, e.g., "The HPV vaccine offers protection against genital warts" and "The HPV vaccine requires at least 2 doses".

The mean GK and VK in our sample was poor at both time points i.e. on average, parents answered around only half the items for both scales correctly, which is consistent with Waller's (2013) and most study results (Davlin et al., 2015; Holcomb et al., 2004; Joseph et al., 2015; Klug et al., 2008). Item-level analysis showed a similar ranking of knowledge items compared to Marlow et al.'s study (n =2409 participants living in the UK, US, and Australia, $M_{age}$= 41-48, with 12-14% of them having daughters aged 9-17 (2013). This may suggest a pattern among the general population where most individuals, regardless of parental status, know about the association between HPV and cervical cancer and that increasing the number of partners increases the risk of HPV. In both our and Marlow et al's sample, most individuals did not know that "Most sexually active people will get HPV at some point in their lives". These results suggest that there may be knowledge gaps that are widespread among different subsamples (e.g., parents, young adults), and that parents are not acquiring any additional knowledge beyond the general population. Educational interventions, dispersed in many widespread channels could target these specific knowledge gaps.

Both GK and VK total scores increased statistically significant over time but the effect size was small (Cohen's d <0.3 for the 1427 sample). At Time 1, we provided a brief informative statement about HPV after the knowledge section, but we estimate that the impact on knowledge at follow-up was very small, considering the nine months' time interval between baseline and follow-up. A closer examination at the item level reveals that correct responses remained consistent for at least nine months. Moreover, at T2, only a tiny proportion (between 0.8 and 12%) of correct responses can be attributed to a change from incorrect at T1 to correct at T2 and

a small proportion (10%-51%) can be attributed to a change from 'Don't know' at T1 to correct at T2. Therefore, we suggest providing both general HPV and HPV vaccine information/facts, with emphasis on the items that parents do not know, rather than correcting misconceptions. As an example, specifying the age and gender recommendation in one's country is advisable. This is further substantiated by our results which showed an overall pattern across both GK and VK items where few individuals answered items *incorrectly* as compared to an often higher proportion of participants who answered 'Don't know', indicating *a lack of HPV knowledge* rather than *wrong/mis*information.

Our study is not without limitations. Firstly, our response rate, calculated based on completion by participants who began the questionnaire *(n*=5733 at T1 and *n*=1999 at T2), was modest (66% at T1 and 80.4% at T2) but superior to other studies (Blake et al., 2015; Gowda et al., 2012). Secondly, a high attrition (49.9%) can be expected in online surveys, but we believe that the effect on our results was minimal due to very few significant changes between the baseline and follow-up sample (see Perez et al., Study Protocol. Under review), and a large sample at T2. Third, although Leger aimed to maintain a nationally representative panel of Canadians, there may be differences between panel members and the general Canadian population (see Perez et al., Study Protocol. Under review). Fourth, we made a few semantic changes to Waller et al.'s scale, which though minimal, result in an imperfect replication. Lastly, the internal consistency was lower amongst French speakers compared to English, and the reason for this requires further exploration.

It remains challenging to compare HPV and HPV vaccine knowledge across studies as researchers vary extensively in the number of items used (e.g., some use as few as three items (Allen et al., 2010; Pelucchi et al., 2010), different response options (e.g., multiple choice, true-false, yes/no/not sure, Likert scale, open-ended) and differing content (Davlin et al., 2015; Giede et al., 2010; Klug et al., 2008). We strongly encourage researchers to utilize the extended GK23 scales to measure HPV knowledge and the VK11 to measure HPV vaccine knowledge, which could allow for comparisons on the overall knowledge level as well as the item level. Additionally, beyond English and French, future researchers could translate these scales to other languages and evaluate the validity among different languages and populations.

***Conclusions***

Our extended HPV general knowledge and HPV vaccine knowledge scales are reliable and unidimensional in both English and French, and capture issues related to both genders. Interestingly, the added items tended to be least known, which suggests parents may know specific facts about HPV better (e.g. the link with cervical cancer; that HPV is an STD) than others (e.g., the link with oral/anal cancers). We suggest educational interventions to inform about the updated points about HPV and the HPV vaccine that are least known and to focus on providing information rather than correcting misconceptions. In our opinion, our comprehensive HPV knowledge scales can significantly contribute to the understanding of how knowledge can influence vaccine decision-making, and in turn improve, HPV vaccination uptake.

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**Conflict of Interest:**

Zeev Rosberger reports personal fees from Merck outside the submitted work at a consultation meeting in November, 2015; and speaker to family physicians in April, 2015. Gregory Zimet reports grants from Merck, grants from Roche, personal fees from Merck, outside the submitted work.

## **Supplemental file:** Appendix A – English HPV General Knowledge (GK) Items[1]

| | **Please answer the following questions to the best of your ability:** |
|---|---|
| 1. | HPV is very rare (F) |
| 2. | HPV always has visible signs or symptoms (F) |
| 3. | HPV can cause cervical cancer (T) |
| 4. | HPV can be transmitted through genital skin-to-skin contact (T) |
| 5. | There are many types of HPV (T) |
| 6. | HPV can cause HIV/AIDS (F) |
| 7. | HPV can be passed on during sexual intercourse (T) |
| 8. | HPV can cause genital warts (T) |
| 9. | Men cannot get HPV (F) |
| 10. | Using condoms reduces the chances of HPV transmission (T) |
| 11. | HPV can be cured with antibiotics (F) |
| 12. | Having many sexual partners increases the risk of getting HPV (T) |
| 13. | HPV usually doesn't need any treatment (T) |
| 14. | Most sexually active people will get HPV at some point in their lives (T) |
| 15. | A person could have HPV for many years without knowing it (T) |
| 16. | Having sex at an early age increases the risk of getting HPV (T) |
| 17. | HPV can cause anal cancer (T) |
| 18. | HPV is a bacterial infection (F) |
| 19. | HPV can be transmitted through oral sex (T) |
| 20. | HPV can cause cancer of the penis (T) |
| 21. | HPV can cause herpes (F) |
| 22. | HPV can be transmitted through anal sex (T) |
| 23. | HPV infections always lead to health problems (F) |
| 24. | HPV can cause oral cancer (T) |
| 25. | A person with no symptoms cannot transmit the HPV infection (F) |

[1] Items 1-16 are from Waller et al.'s scale. Items 17- 25 were added in this study. Items 13 and 21 could ideally be removed, leaving a 23-item solution (GK23). We leave this to the discretion of the researchers. Response options are: *True, False, Don't know*.

## **Supplemental file:** Appendix A – English HPV Vaccination Knowledge (VK) Items[2]

| | **Please answer the following questions to the best of your ability:** |
|---|---|
| 1. | The HPV vaccine[3] requires only 1 dose (F) |
| 2. | The HPV vaccines[4] offer protection against all sexually transmitted infections (F) |
| 3. | The HPV vaccines[4] are most effective if given to people who've never had sex (T) |
| 4. | Someone who has had the HPV vaccine cannot develop cervical cancer (F) |
| 5. | The HPV vaccines[4] offer protection against most cervical cancers (T) |
| 6. | One of the HPV vaccines[4] offers protection against genital warts (T) |
| 7. | Girls who have had the HPV vaccine do not need a Pap test when they are older (F) |
| 8. | The HPV vaccine protects you from every type of HPV (F) |
| 9. | You can cure HPV by getting the HPV vaccine (F) |
| 10. | The HPV vaccine is approved and recommended by Health Canada for females aged 9-45 years (T) |
| 11. | The HPV vaccine is approved and recommended by Health Canada for males aged 9-26 years (T) |

[2] Items 1-7 are from Waller et al.'s scale. Items 8-11 were added in this study. Items 10 and 11 can be adapted to each specific country or regions policy/recommendation. Response options are: *True, False, Don't know*.
[3] We recommend modifying this item to: *The HPV vaccine requires at least 2 doses* (T).
[4] We recommend using *HPV vaccine* (singular) throughout the VK items instead of *HPV vaccine**s*** (plural) as this can be confusing to the reader. For item 6, we recommend the item be asked as follows: *The HPV vaccine offers protection against genital warts.*

| | **Veuillez répondre aux questions suivantes du mieux que vous le pouvez:** |
|---|---|
| 1. | Le VPH est très rare (F) |
| 2. | Le VPH présente toujours des signes ou symptômes visibles (F) |
| 3. | Le VPH peut causer le cancer du col de l'utérus (V) |
| 4. | Le VPH peut se transmettre par contact génital peau à peau (V) |
| 5. | Il existe plusieurs types de VPH (V) |
| 6. | Le VPH peut causer le VIH ou le sida (F) |
| 7. | Le VPH peut être transmis au cours de relations sexuelles (V) |
| 8. | Le VPH peut causer des verrues génitales (V) |
| 9. | Les hommes ne peuvent pas contracter le VPH (F) |
| 10. | L'utilisation d'un condom réduit les chances de transmission du VPH (V) |
| 11. | Le VPH peut être guéri avec des antibiotiques (F) |
| 12. | Avoir de nombreux partenaires sexuels augmente les risques de contracter le VPH (V) |
| 13. | Le VPH ne nécessite habituellement pas de traitement (V) |
| 14. | La plupart des personnes sexuellement actives contracteront le VPH à un moment ou à un autre de leur vie (V) |
| 15. | Une personne pourrait être atteinte du VPH pendant de nombreuses années sans le savoir (V) |
| 16. | Avoir des relations sexuelles à un jeune âge augmente les chances d'attraper le VPH (V) |
| 17. | Le VPH peut causer le cancer de l'anus (V) |
| 18. | Le VPH est une infection bactérienne (F) |
| 19. | Le VPH peut être transmis par sexe oral (V) |
| 20. | Le VPH peut causer le cancer du pénis (V) |
| 21. | Le VPH peut causer l'herpès (F) |
| 22. | Le VPH peut être transmis par sexe anal (V) |
| 23. | Les infections au VPH entraînent toujours des problèmes de santé (F) |
| 24. | Le VPH peut causer le cancer de la bouche (V) |
| 25. | Une personne ne présentant pas de symptômes ne peut pas transmettre le VPH (F) |

## Supplemental File: Appendix B – French HPV General Knowledge Items[5]

## Supplemental File: Appendix B – French HPV Vaccination Knowledge (VK) Items[6]

| | **Veuillez répondre aux questions suivantes du mieux que vous le pouvez:** |
|---|---|
| 1. | Le vaccin[7] contre le VPH ne nécessite qu'une seule dose (F) |
| 2. | Les vaccins[8] contre le VPH protègent contre toutes les infections transmises sexuellement (F) |
| 3. | Les vaccins[4] contre le VPH sont les plus efficaces lorsqu'ils sont administrés à des personnes n'ayant jamais eu de rapports sexuels (V) |
| 4. | Une personne ayant été vaccinée contre le VPH ne peut pas développer le cancer du col de l'utérus (F) |
| 5. | Les vaccins[4] contre le VPH protègent contre la plupart des cancers du col de l'utérus (V) |
| 6. | L'un des vaccins[4] contre le VPH protège contre les verrues génitales (V) |
| 7. | Les filles ayant été vaccinées contre le VPH n'ont pas besoin de passer de test Pap lorsqu'elles sont plus âgées (F) |
| 8. | Le vaccin contre le VPH vous protège contre tous les types de VPH (F) |
| 9. | Vous pouvez guérir le VPH en recevant le vaccin contre le VPH (F) |
| 10. | Le vaccin contre le VPH est approuvé et recommandé par Santé Canada pour les filles/femmes de 9 à 45 ans (V) |
| 11. | Le vaccin contre le VPH est approuvé et recommandé par Santé Canada pour les garçons/hommes de 9 à 26 ans (V) |

[5] Items 1-16 are from Waller et al.'s scale. Items 17- 25 were added in this study. Items 13 and 21 could ideally be dropped, leaving a 23-item solution (GK23). We leave this to the discretion of the researchers. Response options are: *Vrai, Faux, Je ne sais pas*.

[6]Items 1-7 are from Waller et al.'s scale. Items 8-11 were added in this study. Items 10 and 11 can be adapted to each specific country or regions policy/recommendation. Response options are: *Vrai, Faux, Je ne sais pas*.

[7] We recommend modifying this item to: *Le vaccin contre le VPH nécessite au moins deux doses* (T).

[8]We recommend using Le vaccin contre le VPH (singular) throughout the VK items instead of les vaccins contre le VPH (plural) as this can be confusing to the reader. For item 6, we recommend the item be asked as follows: *Le vaccin contre le VPH protège contre les verrues génitales.*

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